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Industrial Waste Diversion Program

Final Reports #2

"USED CAN"

ELECTROLYTIC DETINNING

JUNE 1991

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: Harrison, J.

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"Used Can" Electrolytic Detinning

Report prepared for :

Waste Management Branch
Ontario Ministry of the Environment

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"USED CAN" ELECTROLYTIC DETINNING

Report prepared for:

Waste Management Branch
Ontario Ministry of the Environment

In consultation with

Research Laboratories Metal Recovery Industries Inc.

Report prepared by:

J. Harrison, P. A. Walters, and A.W. Kellner

DISCLAIMER

This report is in partial fulfillment of conditions of a grant given to Metal Recovery Industries Inc. by the Ministry of the Environment under the Industrial Waste Diversion Program. The report was prepared by J. Harrison, P.A. Walters and A.W. Kellner for Metal Recovery Industries Inc. and documents results of work for which the Ministry of the Environment provided financial assistance.

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Tables, Graphs and Appendices

1. INTRODUCTION

There is an increasing supply of tin plated steel cans available for recovery by the steel mills as a direct result of recycling programs such as the Ontario Blue Box Program. The steel manufacturers are currently accepting this scrap "as is", even though it is not a very desirable scrap for re-melt because it contains many contaminants such as debris, aluminum, paper, lacquer and tin. Tin is an especially critical impurity for steelmakers as it cannot be refined out of steel and has very deleterious effects on the ductility of steel. It is therefore believed necessary to develop a process which could separate physical contaminants and remove metallic impurities in order to produce a high grade steel scrap which would have complete and unlimited acceptance by the steel mills, even during times of reduced production or restrictions due to quality requirements. It is anticipated that the operation could be designed such that small "satellite" plants would be built to service many individual municipalities, thereby minimizing the very substantial handling and transportation costs associated with the recycling of used cans.

The preliminary research conducted by Metal Recovery Industries Inc. involved the evaluation of scrap shredders, air classifiers and magnetic separators which would be used to upgrade the steel scrap for detinning by removing debris, paper labels, residual foodstuffs and aluminum. The shredding would also be a form of scrap densification which would aid in the miniaturization of the detinning plant and put the scrap in a form which would be economical to transport and readily useable by the steel companies. It is also possible that this form of scrap could have "added value" if it could be demonstrated that it was acceptable as a high grade, large surface area coolant for the steel mills. Coolant is high grade steel scrap which is added to molten steel when it has been refined and ready to pour, thereby quickly lowering the temperature to the required level in a very short period of time, which then reduces the processing time.

We know that the lacquer and tin from the used cans can be removed by the identical

chemical leaching process used by MRII for the detinning of "prompt" canmakers scrap. However, it has been shown in research work conducted in the mid-1970's using our standard chemical detinning process that the associated impurities of the used cans substantially interfere with the economical processing and recovery of quality tin products. It is also known that the use of chemical oxidants contribute to air and water pollution. It is therefore expected that a one step electrolytic detinning/tin recovery process would have many benefits. An electrical charge would be applied to the scrap to oxidize the tin which would then be directly recovered as tin metal. Direct electrolysis would require a smaller production area and it would regenerate caustic soda, thereby reducing reagent consumption, waste treatment and disposal costs, in general.

The feasibility of electrolytic detinning was investigated in laboratory studies using a rotating plating barrel. The effect of temperature, free alkali, and anodic and cathodic current densities were studied using prompt and post consumer scrap. The effect of agitation and scrap bulk density were also monitored. This lead to recommendations for the operation of a pilot plant. The laboratory studies were performed as a batch operation. It was desired to increase production throughput by use of a continuous process. Thus a pilot plant was designed and built to process large, more realistic, quantities of feed material.

The following report is a summary of the results obtained from the operation of the pilot plant.

2. OBJECTIVES

Laboratory evaluations have been based on a batch process. It is desirable and essentially mandatory, from an engineering perspective, to operate a larger scale pilot plant facility for continuous processing in order to resolve process uncertainties and to generate process data which are required to engineer a full scale facility.

The uncertainties of the process which must be resolved are: -the optimum temperature and caustic soda concentration required to obtain adequate detinning and tin recovery; -the degree of detinning at various speeds and various depths of feed; -the effect of bulk density of the scrap and its physical configuration on the detinning process; -the build up effects of aluminum and organic impurities on the system as well as minor impurities; -the efficiencies, purity and form of tin metal collected from the system.

The engineering data required for a full scale plant are: -the power requirements and efficiencies; -quantities and rates of processing; -the effectiveness of different shredding and mechanical separation (clean up) techniques and equipment for post consumer cans; -the effects of cathode design and placement with respect to the anode (scrap) on efficiencies, purity and form of tin metal collected as well as its method and ease of removal.

3. EXPERIMENTAL

The pilot plant consisted of an insulated steel tank with a 180 ft^3 capacity. The solution was heated by a steam heat exchanger and a recirculation pump was used to keep the solution homogenous. A conveyor was placed in the tank with a submersed volume of 2.8 ft^3. The conveyor was coated on the outside with an epoxy resin. Due to premature failure, this was later replaced with a rubber coating on both sides of the conveyor and the auger. A 10 inch wide strip of steel placed along the bottom of the conveyor served as the anode contact. Two cathodes were prepared from mild steel measuring 24 inches by 27 inches with a total combined surface area of 18 ft^2. These were suspended several inches above the conveyor by insulated copper bus bars. The rectifier could supply 5000 amperes at 30 volts. A soft water spray rinse system was installed near the exit point on the conveyor to rinse the scrap and reduce dragout. Refer to Appendix A for the diagrams of the pilot plant and actual dimensions and setup.

The tank was initially filled with approximately 164 ft^3 (4600 L) of 70 g/L caustic soda solution and heated to the desired temperature. The hopper was loaded with 2 to 4 drums (7 ft^3 each) of shredded scrap at a time. Later, a feed conveyor was added to improve the consistency of scrap loading in the system. The scrap was weighed onto this conveyor so that it could enter the detinning conveyor at a uniform rate. The conveyors speeds were maximized to fill up the detinning conveyor as quickly as possible. The desired speed setting was selected once the detinning conveyor was fully loaded with scrap. A current was applied to the scrap as it travelled along the detinning conveyor. The black scrap was collected in drums or steel boxes and was sampled at regular intervals. The samples were washed, oven dried, and analyzed for tin by acid digestion and titration with potassium iodate. Soft water was added to the tank periodically to replace the water lost by evapouration. When necessary, the alkalinity was increased with the addition of 50 wt per cent sodium hydroxide. The solution was monitored for tin and impurities by atomic absorption spectroscopy and for free and total alkalinity by Standard Test Method XI-Sn-4.

4. RESULTS AND DISCUSSIONS

A) Temperature

In laboratory studies, it was determined that increased temperature improved detinning. It was also discovered that an interaction effect existed between temperature and free alkali. At a higher free alkali (87 g/L), temperature has a greater effect on the residual tin content of the scrap than at a lower free alkali (40 g/L). This was exhibited in pilot plant trials. For example, at 40 g/L free alkali, 1000 A, the tin remaining on the black scrap was 0.135% for both 180°F and 200°F. At a higher free alkali of 100 g/L, increased temperature significantly reduced the residual tin levels of the black scrap as shown below. The anodic current efficiencies were also improved.

Table I

Electrolytic Detinning Characteristics vs. Temperature

Temp (°F)	160	180	200
% Tin	0.119	0.075	0.067
% Anodic C.E.	17.7	19.5	21.0

Laboratory studies show that cathodic current efficiencies are also improved at higher temperatures. (refer to Research Report 1988 - 7; Electrodetinning: Second Progress Report).

Temperatures to 220°F were investigated and it would appear that a temperature of 200°F would be the optimum.

B) Free Alkali

The free alkali was varied from 40 g/L to 200 g/L NaOH. The rate of detinning improved with increased caustic as shown in Table II. With each addition of caustic soda to the solution, chemical detinning was enhanced and then tapered off as the solution was "broken in". This phenomena was observed in laboratory studies as well. One theory is that the dissolved oxygen in the caustic soda enhances chemical detinning until it is consumed.

Table II

The Effect of Free Alkali on Electrodetinning
(for 40 minute runs @ 200°F)

Free Alkali (g/L)	Scrap Load (lbs)	Current (A)	Anodic C.D. (ASF)	% Tin on Black Scrap	% Anodic Current Efficiency
82	270	0	0	0.110	-
176	270	0	0	0.081	-
192	270	0	0	0.057	-
40	133	1000	1.26	0.135	15.4
104	133	1000	1.26	0.067	21.0
84	260	1750	1.07	0.071	13.4
175	274	1750	1.03	0.052	16.1
192	259	1750	1.09	0.053	14.9

Another benefit of increased alkalinity of solution is that the operating voltage is reduced. For example, at 200°F, 1750 A:

NaOH (g/L)	Voltage
84	11.6
146	9.5
200	8.2

The increased caustic soda concentration (reported as "free alkali") appears to improve the conductivity of the solution. The reduced voltage would result in lower power consumption and costs.

Higher caustic soda levels appear to reduce the anodic current density required to produce the minimum residual tin on the black scrap while obtaining the maximum anodic current efficiency. At 100 g/L free alkali and 180°F, it was determined that 1.3 ASF was the optimum current density. At 150 g/L free alkali, this value was reduced to 0.4 ASF. Thus, the power consumption could be significantly reduced.

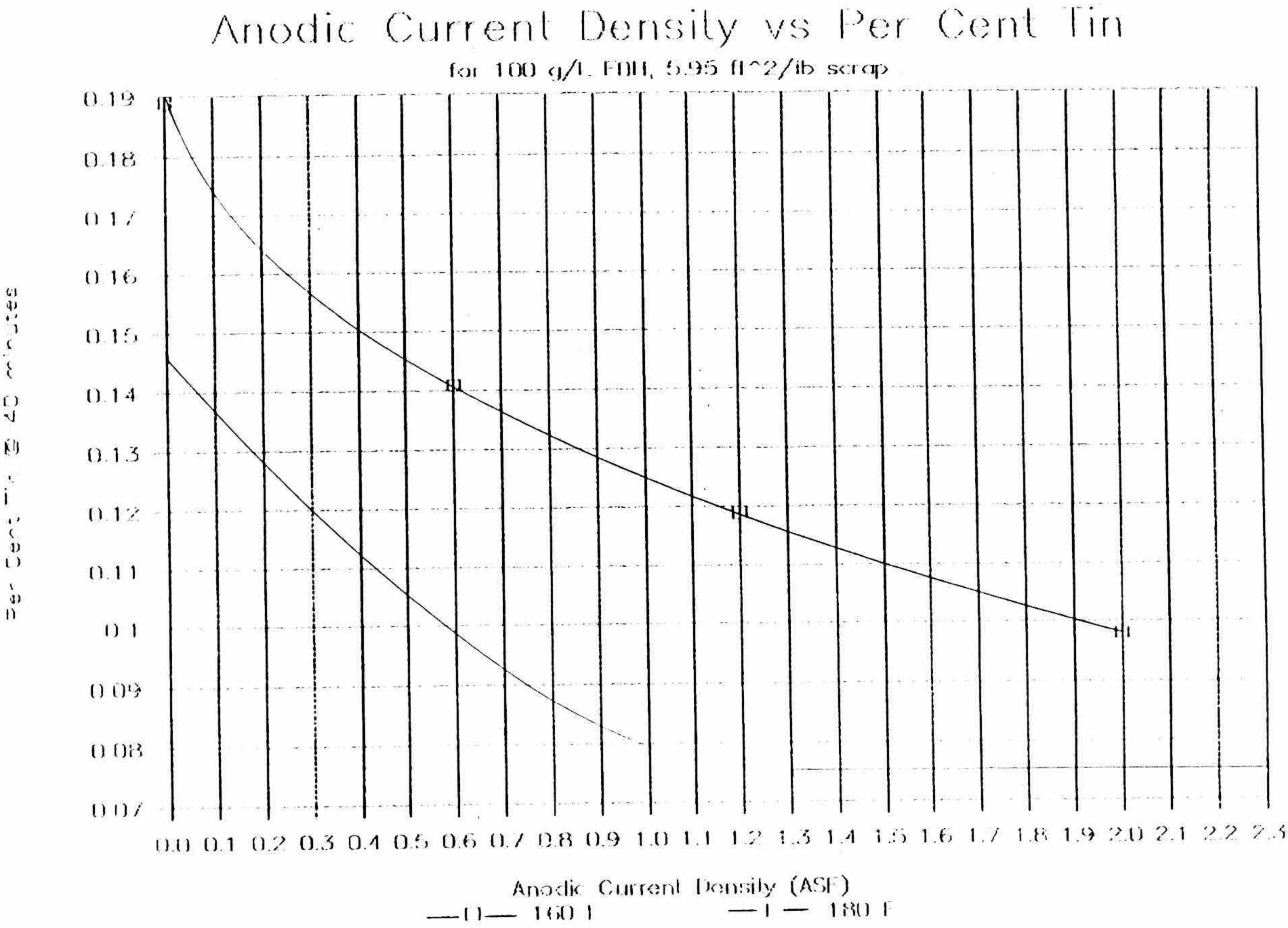
In the range studied, 200 g/L free alkali produced the best results, ie. low residual tin contents with higher anodic current efficiencies and requiring less voltage.

C) Anodic Current Density

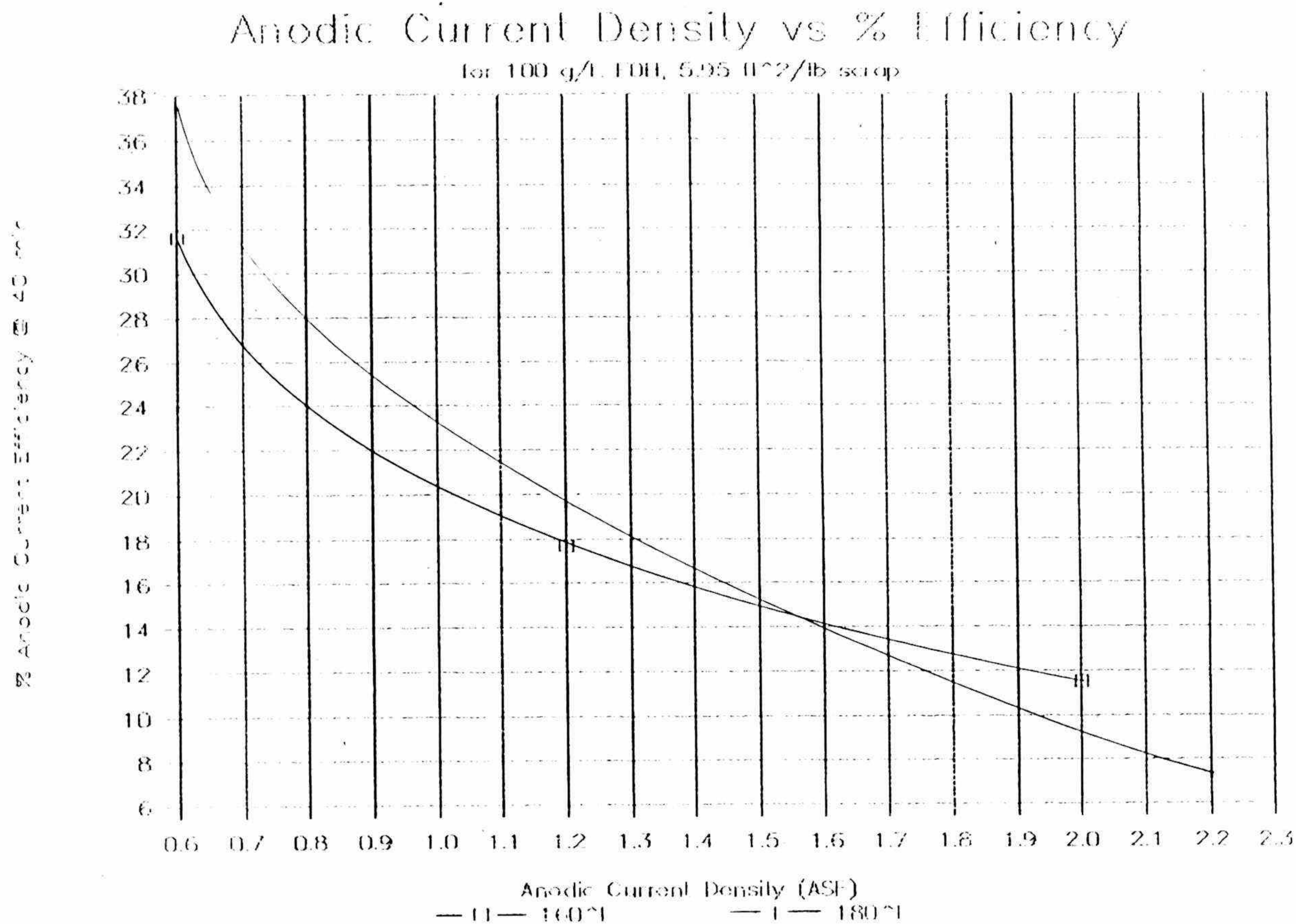
The anodic current density was varied from 0 ASF (chemical detinning) to 3.1 ASF. The residual tin on the black scrap decreased to lower levels as the anodic current density increased. The anodic current efficiencies also decreased as the anodic current density increased. This is displayed in the following graphs.

The optimum anodic current density can be determined experimentally and as mentioned previously, is dependent on the free alkali concentration. A high free alkali reduces the optimum operating current density, thus reducing power costs.

GRAPH I


Anodic Current Density vs Per Cent Tin
for 100 g/L FOH, 5.95 ft^2/lb scrap
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.1
0.09
0.08
0.07
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.1 2.2 2.3
Anodic Current Density (ASF)
160 F
180 F

GRAPH II



Anodic Current Density vs % Efficiency
for 100 g/L FDH, 5.95 ft^2/lb scrap
% Anodic Current Efficiency @ 40 min
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
Anodic Current Density (ASF)
— II — 160°F
— I — 180°F

The applied current, and hence power consumption, can be minimized by minimizing the effective anode contact surface area. This would be performed by minimizing the exposed area of the conveyor, by a form of electrical insulation, to that which comes in contact with the scrap so that only the scrap conducts electricity. This area should be large enough for sufficient contact with the scrap, but small enough to limit the electrolysis of the solution. When the initial epoxy coating on the conveyor had peeled off, runs with and without current produced black scrap of similar quality. The applied current was electrolyzing the solution preferentially to detinning the scrap. The conveyor and auger were then both insulated with a rubber coating. A strip of steel 10 inches wide was placed along the bottom of the conveyor as the anode contact. Runs with current produced substantially lower residual tins in the black scrap than when no current was applied. The importance of the coating was evident, however a suitable material that is able to withstand the corrosive conditions of the process is necessary. After several runs, the coating on the auger and inside the conveyor was badly scratched and worn from the abrasion of the scrap.

D) Conveyor Loading

The anodic current density was varied by altering the load on the conveyor. The load is defined as the weight of scrap anodically charged at any given time. The loading on the conveyor was varied from 120 to 500 pounds.

Decreasing the anodic current density by increasing the load, produced detinned ("black") scrap with the same or slightly lower residual tin content and with higher anodic current efficiencies, when all of the other variables were kept constant. For example, at 200°F, 180 g/L NaOH, 1750 A, and a 40 minute resident time, a load of 274 pounds produced black scrap of 0.052% tin with 16% current efficiency. Under similar conditions, 460 pounds could be detinned to the same level, but with 29% current efficiency.

This appeared to indicate that the wear/contact plate on the bottom of the conveyor was not completely covered when small loads of scrap were processed and that it was free to electrolyze the solution. Larger scrap loadings, in all cases, resulted in improved anodic current efficiencies.

E) Resident Time

Resident times of 40 minutes and 80 minutes were employed in the pilot plant. With high loadings of greater than 400 pounds, only a 40 minute resident time could be utilized as the conveyor stalled at the slower speed. With resident times of less than 40 minutes, the conveyor would jam frequently.

The longer resident time of 80 minutes produced black scrap with lower residual tin contents, but also lower anodic current efficiencies. For example, at 200°F, 1750 A, 175 g/L NaOH and a load of 400 pounds, 0.053% tin was obtained in 40 minutes as compared to 0.037% tin in 80 minutes. The anodic current efficiencies were 29% and 16% respectively.

The rate of detinning is significantly slower in the pilot plant than in the previous laboratory studies. In the laboratory, shredded scrap (including post consumer) could be successfully detinned within 40 minutes, and in as little as 10 minutes depending on the operating parameters. In the pilot plant, 2 to 2.5 hours were required to reduce the tin content of the scrap to specification of 0.060% at a caustic level of 80 g/L or less. Only at an increased caustic level of 150 g/L, and high temperature of 200°F, could the scrap be detinned in 40 minutes. In general, it appears that the pilot plant system requires approximately 300 to 400% more time as did the laboratory plating barrel to detin the scrap.

There is greater scrap movement in the laboratory plating barrel which allows for improved solution contact, mechanical abrasion and removal of tin. This is further evidenced by the quality of black scrap. The black scrap collected in the pilot plant had a dark smutty coating on its surface. This coating was not present in the lab produced black scrap. On a dry weight basis this film contained 34.6% iron, 4.7% tin and 1.2% aluminum. The composition would suggest that the tin coating has been removed down to the iron/tin intermetallic layer of the coating of the metal. It is important that this scrap be well washed to remove the excess tin. Unwashed black scrap samples were found to contain 72 % more tin than the washed samples.

Scrap was processed with 1750 A of current for 40 minutes and reprocessed a second time under the same conditions. The second run reduced the tin content only slightly, from 0.053% to 0.041%. Scrap was processed for 40 minutes without current and fed back through the system for another 40 minutes with 1750 A of current applied. The final product quality was comparable. An 80 minute run with 1750 A also produced similar results. By taking advantage of the chemical detinning that is occurring, the power consumption could be reduced by 50%.

F) <u>Bulk Density</u>

The bulk densities of scrap processed in the pilot plant ranged from 21 lbs/ft^3 for shredded pop cans to 67 lbs/ft^3 for shredded juice and food cans. When the pilot plant was initially operated, a hopper was used to feed scrap into the conveyor. The low density scrap bridged in the hopper, thus requiring constant monitoring to ensure adequate filling of the conveyor. The denser material filled the conveyor more easily due to its own weight, but it did not feed uniformly. Thus the denser scrap filled the conveyor with a greater volume. It was observed that the denser scrap of 43 lbs/ft^3 produced black scrap of similar quality to scrap of 21 lbs/ft^3, but with significantly higher anodic current efficiencies. It was concluded that the denser scrap made better electrical contact with itself and the conveyor due to increased loading. The hopper was eventually replaced with a conveyor so that scrap could be fed into the system at a uniform rate.

The dense scrap of 43 lbs/ft^3 also caused the motor to stall at speeds with residence times of 30 minutes or greater. The motor and gears were therefore replaced in order to obtain a slower processing feed without stalling.

The physical configuration of the shredded feed also affected its detinning. Light weight cans such as coffee cans tended to ball up during shredding as opposed to being sheared and left open. This is not desirable as the surface area is not well exposed to the detinning solution. A mixture of coffee and dog food cans that were balled up could not be detinned to an appreciable extent in the pilot plant. Much of the lacquer and paint remained on the black scrap. Some similar coffee cans were cut into strips and detinned in the lab plating barrel. The residual tin content was 0.029%. Under the same conditions the shredded

coffee cans produced 0.070% residual tin. Ninety minutes were required to successfully detin this material as compared to 30 or 40 minutes for other types of shredded scrap. Thus the tight balling of the scrap (possibly aggravated by the type of lacquer) makes this scrap difficult to detin.

G) Wastes from the Process

During the processing of the shredded "prompt" scrap (ie. can makers' scrap), the soluble tin concentration remained fairly constant at 5 to 6 g/L. The soluble aluminum content was also fairly consistent at 4 to 5 g/L. The aluminum in the shredded "prompt" scrap averaged 0.05% by weight. It was estimated that 35 pounds of free NaOH were consumed and/or dragged out per ton of scrap processed at a cost of $5/ton.

Shredded post consumer scrap varies considerably in its aluminum content. This is chiefly due to the extensive use of bimetal containers ("easy open" lids). Their presence greatly reduces the effectiveness of the shredding and separation process. Thus with this type of scrap, large quantities of aluminum will be present. (up to 5.0% by weight).

A significant amount of foaming occurred during processing which was sometimes accompanied by solution overflow. This is due to the hydrogen gas evolved when the aluminum is dissolved by the caustic soda. The feed rate and temperature had to be reduced in order to maintain control of the reaction. After processing 2.6 tons of post consumer scrap, the soluble aluminum content increased significantly from 5.2 g/L to 19.0 g/L. The free alkali dropped gradually from 170 g/L to 140 g/L, but the total alkali and soluble tin concentration remained fairly constant. Approximately 117 pounds of free alkali were consumed per ton of scrap costing roughly $17/ton. This is significantly higher than the value reported for prompt scrap, $5/ton. It is evident that the introduction of large amounts of aluminum in the system results in increased reagent consumption and costs. Research at MRII has shown that the use of lime will precipitate aluminum as calcium aluminate and regenerate sodium hydroxide. Further research is required to determine if this method can be applied to this process.

After several months of processing shredded prompt scrap, several inches of mud were discovered on the bottom of the tank. Pieces of lacquer and debris were also present. It should also be noted that there were sufficient quantities of lacquer and debris suspended in solution to cause frequent clogging of the recirculation lines. The sludge was found to contain 15.9% tin, 12.9% iron and 2.3% aluminum on a dry weight basis. After several months of processing post consumer scrap, the sludge was again evaluated. The metal concentrations appeared to be diluted with increased organic wastes. On a dry weight basis, 7.0% tin, 9.0% iron and 0.7% aluminum were present. This material would be classified as leachate toxic due to its high lead levels (0.8%), but it is possible to recycle this material via a tin smelter.

H) Tin Metal

The operating cathodic current densities ranged from 14 ASF to 97 ASF. Due to the small amount of tin deposited during a trial, the cathodic current efficiencies were not determined and therefore optimization of the deposition process was not conducted.

After 20 drums (2 tons) of scrap were processed, the cathodes were examined. The tin metal plated was hard and light grey in colour. It adhered well to the cathode and could not be scraped off. After an additional 20 drums were processed, the cathodes were re-examined. The sides facing the conveyor yielded very hard, extremely adherent tin metal. The metal on the opposite side of the cathode was powdery in form, and dark grey in colour. This metal adhered poorly to the cathode.

The appearance of the tin metal was similar to the previous observation after a total of 85 drums (9 tons) of scrap were processed through the system. Samples of the tin were obtained and analyzed for tin content and impurities. The tin collected from the side facing the anode (bottom) contained 87.22% tin. Tin from the opposite side (top) was only 40.61% pure. Both samples contained large quantities of lead and iron. The tin was removed from both cathodes with a propane torch.

Table III

The Effect of Current Density on Tin Quality

% Element	Bottom (high C.D)	Top (low C.D.)
Tin	87.22	40.61
Lead	7.8	10.8
Iron	1.6	6.9
Zinc	0.29	0.38
Aluminum	0.04	0.43
Copper	0.04	0.02
Chromium	0.00	0.01
Total	96.99	59.33

Cathodic current efficiencies were studied in the laboratory (refer to Research Report 1988 - 7; Electrodetinning: Second Progress Report). From these and subsequent studies, it was determined that the cathodic current efficiency improves with increased temperature. The cathodic current density was varied from 15 ASF to 98 ASF. There was no significant difference in the cathodic current efficiencies obtained, but it was observed that less gassing occurred at the lower cathodic current densities. The free alkali was varied from 40 g/L to 87 g/L and this appeared to have no effect on the cathodic current efficiencies.

Further testing in the pilot plant is required to determine optimum cathodic current densities. High cathodic current efficiencies are desired but the purity and form of the deposit is also important. The positioning of the cathodes and other process operating parameters may affect these factors, as well as the power requirements.

I) Batch Electrodetinning

Shredded "prompt" and "post consumer" scrap were processed in a batch pilot plant system. A stationary basket measuring 46.5" x 28" deep with a variable width of 12" to 16" was filled with 400 to 550 pounds of scrap. The basket was suspended in a 1500 L tank with cathodes placed on either side. The applied current was varied from 500 to 1500 A. A wash tank, similar to the detinning tank, filled with soft water was used to wash the scrap after detinning.

Severe hydrogen gassing occurred when "post consumer" scrap was utilized due to the aluminum present in the scrap reacting with the caustic soda. The basket had to be lowered a few inches at a time to prevent solution overflow. On average, 3 to 4 hours were required for adequate detinning. With shorter resident times, the scrap in the centre of the basket had higher residual tin contents than the scrap near the sides of the basket (see Pilot Plant: Book #3). The power consumptions ranged from 11 to 63 kWh/lb of tin with anodic current efficiencies of 5% to 13%. The power costs at $0.05/kWh would be between $0.55 to $3.15/lb of tin, or $2.20 to $12.60 per tonne of scrap.

An attempt was made to improve the rate of detinning by bubbling oxygen up through the bottom of the basket at a rapid rate. Only one experiment was performed, but the results showed that the scrap was detinned in half the time. It is not known if the oxygen had the effect on the reaction or just the increased solution circulation as a result of the gas flow.

Bales prepared from the "post consumer" scrap were also detinned in this pilot plant system. On average, these bales weighed 390 pounds with bulk densities of 88 to 118 lbs/ft^3. The baled scrap contained large quantities of lacquer and garbage such as plastic. This caused a thick sludge-like layer to develop on the surface of the detinning solution and the solution itself became quite viscous. These wastes also clogged the solution recirculation lines.

To obtain residual tin levels of 0.060% or less on a scrap washed basis, required resident times of 12 to 24 hours and power consumptions of 16 to 83 kWh/lb of tin. The power costs would be between $0.80 to $4.15/lb of tin (or $3.20 to $16.60/tonne of post consumer scrap), with anodic current efficiencies of 3% to 9%.

There was a significant difference in the levels of residual tin and aluminum on the black scrap, when comparing the lab washed and "as is" samples. The "as is" samples contained 3 to 8 times more tin and aluminum than the lab washed samples. Thus the wash system employed for the bales in the pilot plant was inadequate. The black scrap produced in the continuous system pilot plant did not have a wash stage, just a light spray rinse. Even so, the "as is" samples contained only two times more tin and aluminum as the lab washed samples. It is therefore apparent that it will be much more difficult to wash scrap in the baled form than the loose form.

This batch system had a slower throughput of scrap than the continuous pilot plant. Roughly 400 pounds in 4 hours versus 40 minutes. The anodic current efficiencies were lower for the batch system than for the continuous system. However, the batch system allows baled scrap to be processed. A batch system eliminates the need for a conveyor and the mechanical problems associated with its use.

5. CONCLUSIONS

From the laboratory and pilot plant studies, it is evident that electrolytic detinning of post consumer tin plate scrap is a technically viable process. By maintaining the proper solution chemistry and operating parameters, it was consistently shown that the residual tin content of the processed scrap can be kept below 0.045%. This is well below the steelmakers' specification of 0.06% maximum.

The operating parameters and their interactions were evaluated, resulting in the "optimum operating base" listed below. It is interesting to note that one of the original goals of electrolytic detinning was to use a significantly lower caustic soda concentration and lower temperature than our conventional chemical detinning process. However, in order to optimize the system and reduce power requirements, it was necessary to elevate both of these parameters back to near "original" levels.

Sodium hydroxide	200 g/L
Temperature	85 °C
Anodic Current Density	2 to 3 ASF
Cathodic Current Density	15 to 100 ASF
Residence Time	40 to 80 minutes
Bulk Density	< 60 lbs/ft^3

Perhaps the most significant conclusion of operating the pilot plant is the need for intense clean up of the scrap prior to detinning, via air classification, and magnetic separation. This cannot be over emphasized. Even with this, aluminum will always be a very significant contamination problem, at least until the use of bimetal containers is eliminated. (Steel, "easy open" lids have been used extensively throughout Europe and should be easily adapted to North American marketplaces). Elimination of any debris before detinning would reduce the quantity of sludge in the detinning tank, which will be an important concern. In these studies, 10 pounds (dry weight) of sludge were generated per ton of scrap processed. These "muds" may be dried and the tin reclaimed by a smelting process.

Appendix B contains a cost evaluation for operating a continuous electrolytic detinning facility for post consumer cans. It must be noted that these costs are for discussion purposes only, and that a more thorough investigation is required before a decision on the economical viability of the process is made. However, from the evaluation, it is apparent that some significant changes will be required to allow the process to become a reality.

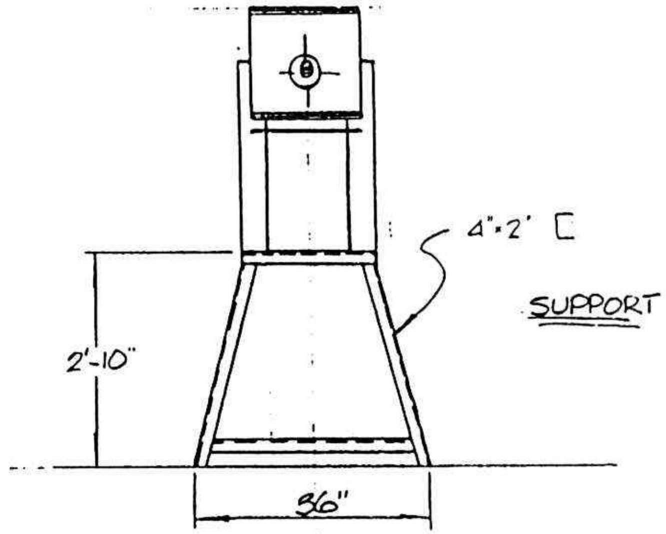
The use of existing land and possibly plant space in Hamilton ("brown field approach") would significantly reduce capital outlay. It is also quite possible that some of the equipment required could be "previously owned", also reducing the capital required. Processing costs would be expected to be reduced to some degree as the process is optimized during full scale operation. However, the most significant cost savings would be in increasing the throughput of the plant. Again, this could be a result of process optimization, but will be really a function of what is available for processing from the community "blue box" program. At the present time, 20,000 tonnes per year of steel cans is seen as optimistic for the Hamilton - Toronto area.

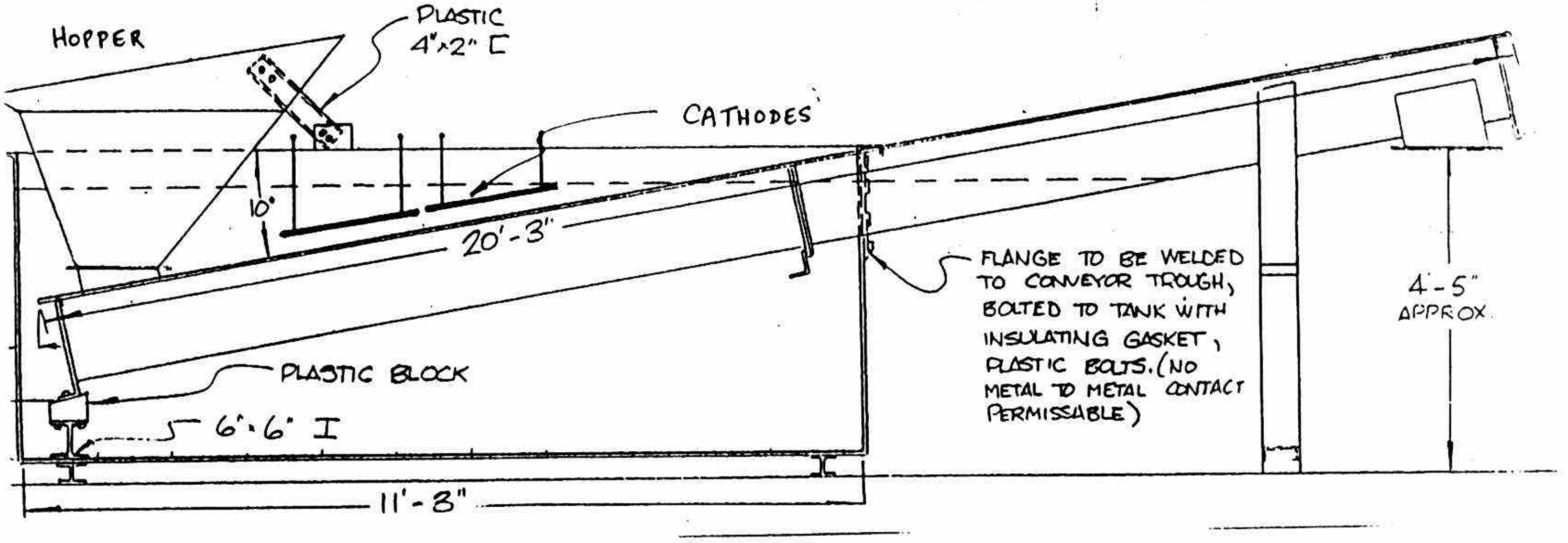
Fitting into the financial evaluations are the values for buying of the scrap and selling of the finished products. The difference between these two values must cover the cost of processing. At present, the steel industry is purchasing used can scrap at what is perceived to be an artificially high level of $70.00 per net ton, in order to promote recycling of their products. However, No. 1 Grade black scrap (detinned scrap) is purchased for $107.00 per net ton. This only allows $37.00 for detinning processing costs. Until a realistic value is established for post consumer scrap (ie. $15 to $20 per ton), it will be difficult to establish a used can detinning plant.

APPENDIX A

Diagram I

DETINNING CONVEYOR





Appendix B

USED CAN DETINNING

CONTINUOUS PRODUCTION PLANT COST ESTIMATES

A. Process Design Assumptions:

- 20,000 tonnes per year production
- land and building value of $ 1,500,000
- capital equipment value of $ 1,500,000
- 8 hours per day, 5 days per week, 48 weeks per year
- 41.67 tonnes per day
- 5.21 tonnes per hour
- initial clean-up and separation will include:
    - magnetic separation of feed
    - air classification and shredding of ferrous fraction
    - screening separation of non-ferrous fraction
    - densification of aluminum fraction
    - screw conveyor material transport through detinning system
- 2 stage electrolytic detinning system
- 2 counter-current wash tanks with fresh water spray headers
- average tin recovery of 1.8 Kg. per tonne

B. ESTIMATED VARIABLE PRODUCTION COSTS: $ per tonne

B1. Scrap Receiving and Preparation:

Receiving, separation and entering into system	$ 5.00

B2. Powerhouse: (Steam)

Process and plant environment requirements	$ 3.00

B3. Electricity:

i)	Shredder and air classifier	$ 4.00
ii)	Conveyors, Cranes, Utilities	$ 2.50
iii)	Electrolysis	$ 5.00
iv)	Wastewater Treatment	$ 2.00

B4. Repairs and Maintenance:

Based on Detinning experience	$ 6.00

B5. Raw Materials:

i)	Caustic Soda	$ 10.00
ii)	Water	$ 0.20

B6. Labour & Variable Overhead:

i)	Direct Labour	$ 5.00
ii)	Indirect Labour	$ 3.00
iii)	Variable Overhead	$ 1.00

B7. Recovered Tin Value:

1.4 Kg. @ $ 4.60	$(6.45)

TOTAL VARIABLE PROCESSING COSTS	**$ 40.25**

C. <u>FINANCING:</u> $ per tonne

C1. Interest ($3,000,000 @ 13%)	$ 19.50
C2. Principal Repayment	$ 15.00
C3. Depreciation (@ 10%)	$ 7.50
C4. Taxes (@ 35%)	$ 8.75
C5. Net Profit Contribution	$ 10.00
TOTAL FINANCING COSTS	**$ 60.75**

D. **TOTAL ESTIMATED FIXED & VARIABLE PROCESSING COSTS:** **$101.00**

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"Used can" electrolytic detinning
: Harrison, J.

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